

論文内容の要旨

博士論文題目

Study on Sensing Technology for Resident' s Behavior Awareness in Home
(宅内における住人の振る舞い認識に向けたセンシング技術に関する研究)

氏 名 柏本 幸俊

(論文内容の要旨)

Thanks to the astonishing progress of the ubiquitous computing technology, Resident' s Behavior Awareness (RBA) with sensors in home attracts the attention. To realize the wide spread use of RBA, it needs to fulfill the following requirements: (i) Adoption of diffusive devices and (ii) Accurate recognition of the context. However, there are few applications realized, since they cannot fulfill the requirements. Thus, the objective of this study is to develop sensing technologies to realize RBA, and to expand applicability of them.

In order to develop a monitoring system for sensing resident' s behavior, we have to implement two functions in the system. One is the indoor positioning and the other is the activity recognition.

The indoor positioning system includes the floorplan creation tool as well as the system itself. The indoor positioning system enables the resident' s behavior awareness application to recognize the surrounding environment of the user. First problem is that there is no floorplan creation tool that adopts diffusive sensors and achieve accurate floorplan creation. In this study, we utilize the prevailed device: smartphone, and develop easy-to-use measurement method: the user completes a lap along the walls of all rooms, and the tool estimates the accurate shape and size of the room. To realize the accurate measurement, we attach the ultrasonic distance measurement sensor to the phone and develop the technique to handle the noise effect from the object attached to wall. The evaluation result showed that the

subject created the accurate floorplan. Through the experiment, we confirmed that we realized the accurate floorplan creation tool with diffusive devices that is essential to RBA.

Next problem is that there is no indoor positioning system that adopts diffusive sensors and achieve accurate positioning of the user. In this thesis, we work on the development of the vibration type estimation technique toward indoor positioning system. The proposed system estimates the position of the user by distinguishing the vibrations that occur when the user interacts furniture. To design the diffusive and low-cost system, we utilize an easy-to-be-concealed and low-cost piezo sensor attached on the floor in home. To improve the recognition accuracy, we utilize Mel Frequency Cepstrum Coefficient (MFCC) feature to estimate the vibration type. Through the evaluation, the system estimated the vibration type with F-measure: 93.9%. Through the experiment, we confirmed that we realized the fundamental indoor positioning technique with diffusive devices that is essential to RBA.

The activity recognition system in home enables the resident's behavior awareness applications to recognize the activity state of the user. However, there is no system that is privacy-aware and utilizes diffusive sensors and performs accurate activity recognition. In this study, we develop an activity recognition system to track resident's behavior in home. The system is making efficient use of PIR door sensors installed in home. To design the diffusive and low-cost system, we adopt the device-free and low-cost energy-harvesting PIR sensor. To improve the recognition performance, we utilize machine learning and supplemental technique for Passive Infra-Red (PIR) sensor's dead zone. The evaluation result showed that the system estimated the user's activity with F-measure: 68.6%. Through the experiment, we confirmed that we realized the accurate activity recognition system with diffusive devices that is essential to RBA.

(論文審査結果の要旨)

本論文は、RBA (Resident's Behavior Awareness), すなわち、家庭内でのコンテキストウェアネスに着目したセンシングおよびデータ解析手法を提案している。RBAのためには、フロアマップの生成、フロアマップ内での住人の位置推定、住人の行動推定の技術が必要である。本論文では、それぞれについて、普及型デバイスのみを用いて、かつ、住人がデバイスを装着しなくても、高い精度で実現する手法を考案、開発し評価した。本研究の学術的貢献は以下の通りである。

- (1) フロアマップを容易に作成するための、スマートフォンに装着可能な低コストの超音波センサガジェットを開発し、本ガジェットとスマートフォン搭載のセンサのみを使った部屋の形状・サイズ推定手法を設計・実現し、実用性能が達成できることを確認した。
- (2) 宅内で、住人がデバイスを装着することなく位置推定できるようにするため、人の移動や家具・ドアの移動時の振動音をキャプチャする床振動センサおよびそのセンサを使った位置推定法を設計・実現し、評価した。
- (3) 宅内で、焦電型人感センサの情報と家電の消費電力情報から複数種類の生活行動を推定する手法を設計・開発し、評価した。

屋内での位置推定、行動推定に関する研究は多くなされているが、普及型センサのみを使った方法についてはあまり例がなく、本研究は、家庭におけるコンテキストウェアネス (RBA) を基としたサービス実現に向けて大きな貢献があると評価する。

以上より、本論文は、博士 (工学) の学位論文として価値あるものと認める。